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ABSTRACT

In a study involving creative spelling, 300 kindergarten children and one first grader used computer programs to spell words in isolation and in stories they wrote. As the children made progress toward writing words in conventional spelling, they developed phonological spelling strategies similar to those that have previously been reported for children using paper and pencils. At the same time, they also developed visual spelling strategies in more detail than previously reported. There was no delay in the development of visual strategies to justify the claim that a new visual state of spelling occurs after a phonetic stage. The development of visual, print-based spelling strategies by the children is discussed in terms of the microcomputer's potential for accelerating the acquisition of spelling skills, and includes the following observations: (1) stage theories of spelling development need to be adjusted to account for visual strategies in more detail before the transitional stage; (2) creative variations that follow a standard spelling are not simply a relapse to a transitional or phonetic stage; (3) sometimes only visual influences, but alternatively alternating and simultaneous visual and phonetic influences, appear in the development of a child's spelling; (4) the computer has exceptional capabilities for making children aware of letter relationships in spelling. A note on how to obtain the computer programs used in this study, 11 tables, and three figures are included. (27 references) (CGD)

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Creative Spelling with Visual Strategies on the Microcomputer

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Abstract

Three kindergarten children and one first grader used computer programs to spell words in isolation and in stories they wrote. As the children made progress toward writing words in conventional spelling, they developed phonological spelling strategies similar to those that have previously been reported for children using paper and pencil. At the same time, they also developed visual spelling strategies in more detail than previously reported. There was no delay in the development of visual strategies to justify the claim that a new visual stage of spelling occurs after a phonetic stage. The development of visual, print-based spelling strategies by the children is discussed in terms of the microcomputer's potential for accelerating the acquisition of spelling skills.

Creative Spelling on the Microcomputer

Much of the recent research in spelling has centered around phonological and visual influences, or strategies, in the development of children's spelling (Barron, 1980; Frith, 1980; Frith & Frith, 1980; Marino, 1980; Nolin & McCartin, 1984; Radebaugh, 1985; Read, 1986; Read & Hodges, 1982). The phonological strategy uses the sounds heard in words to write letters while the visual strategy uses what was seen in words. According to these studies, phonological strategies develop before the visual strategies, and good spellers use visual strategies while poor spellers stay with a phoneme-to-grapheme strategy. Elaborating on these findings, some investigators have described spelling development in terms of stages (Anderson, 1985; Gentry, 1981, 1982, 1987; Henderson, 1985; Morris & Perney, 1984; Morris, Nelson, & Perney, 1986). Gentry (1982), for example, describes a developmental sequence of precommunicative, semiphonetic, phonetic, transitional, and correct spelling.

In these stage descriptions, visual strategies are found primarily in the later transitional and correct spelling stages. Gentry (1982) gives the following account for visual strategies at the transitional stage: "Transitional spellers present the first evidence of a new visual strategy; the child moves from phonological to morphological and visual spelling (e.g. EIGHTEE instead of the phonetic ATE [eighty]). . . . Due to the child's new

visual strategy, transitional spellers may include all appropriate letters, but they may reverse some letters" (pp. 196-197). This does not mean, however, that earlier evidence for visual influences does not occur in the form of earlier standard spellings: "Correct form may account for from 0 to 50% or more of the words in semiphonetic writing, depending largely upon the writer's exposure to reading and the amount and type of instructional intervention experienced" (Gentry, 1982, p. 197). Children's spelling of -s for the plural morpheme has also been regarded as an early visual influence (Marsh, Friedman, Welch, & Desberg, 1980, p. 346). Visual strategies, however, have not normally been described in more detailed development until the transitional stage.

Gentry's qualification that the proportion of correct spellings depends upon children's background is important. For example, Gates and Chase (1926/1976) reported that congenitally deaf children were better spellers than hearing children of an equivalent reading level. Gates and Chase attributed the spelling skills of the deaf to their "peculiarly effective type of perceiving, of reacting visually to words" (p. 349). The superiority of these deaf children seems at least partially due to their earlier and/or greater reliance on visual strategies.

If there are advantages to visual strategies and if background influences can make a difference, it would seem worthwhile to investigate the effects of spelling activities

that emphasize the visual information in spelling. Accordingly, the following examines children's spelling development under the influence of computer programs that presented a considerable amount of visual information in addition to phonetic information.

Method

Subjects and setting. We worked with four children, one first grader (Julian, 6 years, 4 months) and three kindergarteners (Beth, 6 years, 1 month; Kathy, 5 years, 5 months; and James, 6 years, 3 months) in a day care center they attended after school. An initial assessment in reading a three sentence paragraph based on the vocabulary words in the computer programs showed that Julian read aloud all the words correctly, James read most of the words, Kathy read none of the words, and Beth named some letters instead of reading the words. We worked in a room that was rarely used by the other children while we were there.

Apparatus. The children worked on an Apple IIc computer with an Echo General Purpose Speech Synthesis Unit. The use of "pronounced" in the following procedures refers to pronunciation by the speech synthesis unit.

Instructional Procedures. Computer programs, which had previously been developed in Terrapin Logo by the first author, were used for copying, spelling, and story writing (Moxley, 1986; Moxley & Barry, 1985; Moxley & Barry, 1986). The DC (Direct Copy) and SPELL programs, which included read-write cycles (Lee & Sanderson, 1987) with immediate

correction (DiStefano & Hagerty, 1985), and one of the three programs for writing stories--PW (Picturewriting), WP (Word Pictures), and SE (Story Editor)--were used in every session. For the most part, the use of these programs required the Caps Lock key to be depressed. Although the WP and SE programs allow lower case letters to be written for the stories, we did not give children this option until their last few sessions.

In the DC program, 10 to 15 words that would be useful in writing sentences in the story writing programs, or had been requested by the child, were entered in the program vocabulary. These words were changed weekly as the child learned how to spell and read the words correctly. One at a time in random order without replacement, 10 of these words were then displayed on the screen and pronounced. Pressing the return key at any time would repronounce the word. As the child copied the word, the letter for each key press was displayed on the screen beneath its corresponding location in the model and recorded by the computer. Correct letters remained on the screen and incorrect letters disappeared after a brief "flash" until the entire word had been copied correctly. The model was then highlighted, pronounced, and one or more stars appeared, corresponding to the cumulative number of words copied correctly, until ten stars were shown or four minutes had passed. The children soon completed their 10 words before the time limit expired.

The SPELL program was similar to the DC program except the model word disappeared once a correct letter key was pressed. This allowed the child to study the visual appearance of the word without any time constraint other than the total of four minutes allowed. The word reappeared when an incorrect key was pressed or when the child pressed the return key.

Initially in both programs, the name of the correct letter was pronounced when it was typed in. Later, in Beth's third phase, this was changed so that the series of correct letters typed in so far were pronounced as a whole unit when each correct letter was typed in. This change, which was designed to make children more aware of sound/letter relationships within clusters of letters, showed how segments like we in went sounded differently when spelled alone as a word. At this point, we also included more rhyming words in the spelling vocabulary.

After completing the above two programs, a printout of all the words presented, all the keys pressed, and the cumulative number of seconds between key presses was shown to the child. See Figure 1. Positive comments were given for improvements in speed and spelling accuracy. Words read without help were underlined, and help in sounding out other words was given.

Insert Figure 1 about here

After every 20 sessions, the children were given a dictated spelling test, which included the words they had spelled in the DC and SPELL programs during that time.

The first story writing program (PW) was designed to closely map the words the children spoke to the pictures that appeared on the screen. The vocabulary words that produced pictures were put on 3 x 5 cards with the printed word on one side and the picture on the other. The words for pictures included schematic representations of actions as well as objects. See Figure 2. The children then inspected, selected, and copied the words they wanted from the cards. Function words were written on cards as the child needed them. When the standard spelling of the words were typed in, the pictures of the words that had pictures, appeared on the screen in a fixed left to right order.

Insert Figure 2 about here

Within a couple weeks the children were switched to the second writing program (WP). In this program, the children could move the cursor anywhere on the screen for placing their picture, and schematic representations for verbs were no longer used. The children had five minutes to put their pictures on the screen and five minutes to write a story about them. They could still copy from word cards to produce their pictures, but they were to spell the words in

their stories as best they could. Usually, we wrote down what they said about their pictures and dictated it back for them to write, although the children often preferred to compose as they wrote when they became more proficient spellers. Since the children were often reluctant at first to spell words they were unsure of, we said we would help them to revise their words before they were printed out and taken home. Records were kept of both the original and the revised writing. See Figure 3.

Insert Figure 3 about here

The revised story was then read back to the child with the speech synthesis unit. Each word was highlighted and pronounced in turn with each press of the space bar by the child. The whole story was read back by pressing the "3" key. Next, the picture and story were printed out, and the child was asked to read the story. We underlined the correctly pronounced words and gave help in sounding out for the others. When the children were consistently reading all their words correctly, which they all eventually did, we discontinued the speech synthesis reading of their stories.

Later we gave the children the option of using a third program (SE), which used the Logo editor as a basic word processing program. No pictures were used in this program.

We worked with the children in month-long phases that ended in a spelling test. Each phase consisted of approximately 20 sessions each, 4-5 days a week, for approximately 20 minutes per session. Since we were working with an Apple IIc, we took advantage of the opportunity to alternate between the standard Qwerty and the Dvorak keyboard arrangements by pressing the switch for doing this after each phase and rearranging the keys, which easily pry off. This allowed us to see if keyboard influences from working with a previous keyboard would show up in children's creative spellings in their tests and stories even though the children had ample time to correct such errors.

We started out by working with one child for one phase and then added a child and switched keyboard arrangements when we went to the next phase. We continued adding children to work with in this manner until a child had completed four phases or until the academic year ended, as it did after James's third phase.

At the end of each child's experiences on the computer, we asked the child's mother about the effects of these experiences and about influences from home or school that might have made a contribution to the child's writing and reading development.

Results

The creative and standard spellings are listed in Tables 1-4 for the tests and Tables 5-8 for the stories. Additional lists of standard spellings are in Tables 9-11.

All the children showed development in both phonetic and visual spelling categories. In general, their phonetic spelling development was similar to that which has previously been reported for children working with paper and pencil. However, examples of visual spellings appeared from the beginning and continued to appear along with spellings that would be classified as precommunicative, semiphonetic, and phonetic. There was no delay until the transitional stage for "the first evidence of a new visual strategy." Since the literature on children's spelling development has primarily emphasized phonological categories, the visual classifications for the children's spelling will be presented below in some detail.

It should be noted, however, that the spellings in the visual categories cannot all be unambiguously assigned to visual strategies. At times, we must allow for the possibility that a phonological strategy may have made a partial contribution to the spelling of the word. Such instances, however, do not deny at least a partial visual strategy. At other times, we must consider whether an exclusively phonological strategy could also have produced the word. We have noted instances where this alternative interpretation seems plausible. The reader may discover more. However, we do not believe the vast majority of these visual classifications can be solely explained by a phonological interpretation.

Limitations on the plausibility of alternative phonological interpretations are particularly strong when we consider the context in which individual words are spelled. For example, we may be able to explain the correct spelling of some phonetically irregular word as phonetically regular in some dialects. We can explain more spellings that way if we are free to appeal to different dialects for each different word, but we have much less freedom for this kind of interpretation when we must retain the same dialect across all the words spelled by the same child. In addition, there are developmental sequences of individually spelled words that make sense in terms of visual categories but not phonological categories. For example, although standard spellings for phonetically regular words may result from a phonological strategy as well as a visual strategy, this is a much less plausible interpretation if the child has not yet achieved a phonetic stage of spelling development. For that reason, most standard spellings of phonetically regular words before the phonetic stage are more plausibly interpreted as requiring visual strategies.

Insert Tables 1-8 about here

Visual Categories

Standard Spellings

On the spelling tests, there was a substantial range in the percentage of standard spellings from Beth to James. See Table 9. Beth never exceeded 36% (her first test). James never fell below 82% (his first test). When they had substantially fewer different words to spell and more opportunities to spell them, Beth (her first test) and Kathy (her third test) had their highest percentages of standard spellings. Fewer words and more opportunities to spell each word made less difference with James (his second test), who had a consistently high percentage of standard spellings on all three of his tests. For all of the children, most of the words that were always spelled correctly in the stories were words that were among the program vocabulary words they had spelled (words without the asterisk). See Table 10.

Insert Tables 9 and 10 about here

Many words were spelled in standard form that had earlier or later creative variations. These are displayed in Tables 1-4 for the spelling tests. The numerals within Tables 5-8 indicate the number of times the standard spelling occured in the stories. From the first to last phase, Julian's standard spelling totals were 34, 32, 51, and 29 respectively, Beth's were 4, 20, 91, and 140, Kathy's

74, 81, 98, and 82, and James's 18, 46, and 85. The phase totals of standard spellings for each child steadily increased for the first three phases and declined in the fourth except for Beth, who showed the highest increases between phases and the highest single phase total of all the children.

Although most of the standard spellings were always spelled in standard form after they had been acquired, several standard spellings were followed by creative variations. There was also a fairly wide range of different types of creative spellings that preceded and followed the standard form. Many of these spellings would not be classified as transitional. Further details are presented in the Discussion section.

Analogical wholes: the standard spelling of a related word.

This is a new category from those that are commonly described in transitional spellings. The influencing word may sound alike, look alike, or be an alternative form of the word heard. Some of these spellings may also result from phonological strategies that produce words which coincidentally resemble other words. Other spellings like RUN/ran, RUNS/run, RAN/run, HOUSE/horse, and INDIAN/Indians are more clearly under the control of similar word forms.

Julian spelled RUN/ran, SAD/said, SEES/see, RUNS/run, COLD/cloud, HOUSE/horse, SLID/sled and WIN/when in tests and INDIAN/Indians, SAD/said, BYE/by, DAD/did, GET/getting, and BENT/bunny in stories. Beth spelled PAT/sat, HAT/hit,

PIT/pot, PAT,put, and RAN/run in tests and TO/two, SLED/sliding, WASHING/watching in stories. Kathy spelled SEES/see, HERE/there, TO/two, SHOWED/showing, SWAM/swim, and ONE/won in tests and IS/it, SIDE/snowman, STAR/stars, WONT/went, DAD/down, HOG/showed, TO/too, TOO/to, BARN/bear, and WISH/with in stories. James spelled HOUSE/horse, SEAT/sat, SWIM/swam, and SWAM/swim in tests and BYE/by, TRIKCS/tracks (a possible borrowing of tricks) and CARS/chairs in stories.

Analogical parts: letters from related words.

Among the many sources of influence for analogical parts are a similar sounding word like the SEE in PAPSEE/Pepsi, a word commonly used as a segment in other words, like the MAN in CHRISTMAN/Christmas, a related morpheme like the -S in TAKS/track, a recently spelled word, and various combinations of the above.

In tests, Julian's spelling of RUNNS/runs and WALR/water seems to have been influenced by running and walk respectively, SWRING/swing may have been influenced by ring and PAPSEE/Pepsi may have been influenced by see. In stories, CHRISTMAN/Christmas may have been influenced by man a stand alone word and a common segment in words like snowman. WHITCH/witch may have been influenced by which since witch was previously spelled the standard way. In stories, Beth spelled ONECI/WSA/ONES/once, which shows the influence of one, a word she commonly used to start many of her stories ("One day there was . . ."). WSA seems to

represent "Once a" in the new opening phrase she began to use ("Once upon a time . . ."). In tests, Kathy wrote NOWND/snowing and
THEYER/that's, indicating a possible influence from the -ed form of snow and from they respectively, and TRUICK/trick, indicating an influence from truck as well as a possible extra vowel in sounding out. In the first phase of stories, Kathy wrote THC/it which seems to have been influenced by THE which she had already spelled twice in that sentence. In stories, James spelled BOT/bird, which was preceded by BOT/boat in the same sentence, RAIND/riding, which seems influenced by rained, TRAKS/track, an influence of the plural form, and CANPUTER/computer. The CAN in CANPUTER seemed to represent a strong semantic borrowing as though the meaning of computer was that it "can pute." James seemed quite surprised when the standard form was explained to him and was reluctant to revise his spelling. CONPUTER/computer was as far as he would go. He said he preferred CONPUTER to computer.

Standard spellings of a significant segment.

This category includes segments of words that are spelled in standard form while the rest of the word has some creative variation. Most of these segments are the inflections -ing, -ed, or -s. They may also include common morphemes like MAN or letter clusters perceived as a unit by the child like LOON.

In tests, Julian spelled ROKING/walking, SOWNING/snowing, SRE ING/swing (but not in GETINN/getting or TANKSGIVIN/thanksgiving), WOKS/walks, WATES/wants, HIVING/having, SOWNMAN/snowman, WENTED/wanted, WOHED/watched, BAYKED/baked, and BAYKS/bakes. In SRE ING/swing the ING is spatially separated even though in this case it did not represent the inflected form. This indicates the -ing unit had been identified with its corresponding sound and not, at least in this case, with its grammatical function. In stories, Julian wrote, GOINGN/going, EASTTER/easter, and HIVING/hang. GOINGN appears to represent a combination of two distinct strategies for representing the ending of going: the ING segment and a phonetic ending with N which he had used previously with GON and GOEN. In BLOON/balloon on tests, the second syllable is treated as a meaningful segment. Although ball would appear to have been a more likely candidate, the sound of ball is not heard in this word. Beth spelled RNING/raining, WATEED/walked, WTED/wanted in tests and OTING/holding, MEKING/milking, RDTING/riding, SAITING/sitting, SAENING/standing, SARING/staring, YING/WLKING/walking, and EING/YAEING/watching in stories. Kathy spelled SOWING/snowing in tests and ETING/eating, SIDNINING/sitting, and WRING/WINING/wearing in stories. Although he had fewer sessions, James spelled more standard inflections than Kathy. He spelled FLEING/flying, FLEING/FLAING/flying, RADING/riding, SMALING/smelling,

SEWMING/swimming, SWINING/swinging, WAERING/wearing, GATING/getting, HALDING/HALING/holding, MALTING/melting, and SMALING/smelling in stories.

Letter Reversals.

All of the children reversed the sequence of letters in some of their spellings. In most of these reversals, the letters were visually accurate except for their order. Many of these reversals were closely preceded or followed by a standard spelling. In some cases, sounds were reversed. For example, EN CAS/chasing reverses the sounds of chasing, and the MR in PUGMR/Pilgrim may be a similar reversal.

Julian spelled AET/ate, which may also reflect an attempt to represent the diphthongal nature of the vowel /e/, SOWN/snow, SOWNING/snowing, SOWNMAN/snowman, TEERT/treat, AET/ate, BIDR/bird, COLD/cloud, GRIL/girl, PUGMR/Pilgrim, SWA/saw, SOWNBAL/snowball, FNECE/fence, PIAL/pail, and SIAL/sail in tests and EN CAS/chasing, BOFR/before, WATRE/water, KISD/kids, GRIL/girl, and SCOOH/school in stories. Beth spelled AET/ate, DHTN/IDHT/the, SAE/ask, HRE/her, and TOW/two in stories. Kathy spelled SATR/star, REH/her, SEH/she WLEK/walk, SNWN/snow, WAETR/water, CLUD/cold, and TURACK/truck, which may also have been a sounding out of TUR for TR, in tests and FOLS/flower, OTU/outside, STRA/star, WNIT/went, WAS/saw, HES/she, and TO GHTAR/together in stories. James spelled HRA/her, WLAK/walk CULOD/cloud, and TOW/tow in tests and RAOD/road, TRIKCS/tracks, and WAERING/wearing in stories.

Keyboard Influences.

Conspicuous, direct influences of the keyboard on spellings in tests and stories were slight. On occasion, Julian confused the I key with the L key. He spelled TOIC/talk and COID/cold in tests and TAIK/talk in stories. At one time Julian asked if the capital I on the keyboard meant lower case l. Kathy also spelled W;S/was in her fourth phase. Except for Kathy's spelling of OND/one at the beginning of her third story session, where the D is in the position of the previous keyboard's E, none of the children's creative spellings in their tests or stories showed they had been influenced by the key arrangements of the previous keyboard. When the children were given the option near the end of the project of printing stories in lower case letters, no discernible problem was observed when pressing an upper case key cap resulted in a lower case printed letter.

Patterns Among the Children

Although they continued to incorporate new words into their writing, all the children were eventually able to write some stories in standard spelling. This was true even for the two non-readers at the beginning of the study, Beth and Kathy, who worked with a more limited spelling vocabulary. When stories were written with all words spelled correctly, it was often the case that patterns of words were repeated, which made their stories easier to compose and read as well as easier to spell. See Table 11

for some contrastive examples of spellings in stories written earlier and later.

Insert Table 11 about here

Eventually, all the children were able to read their stories aloud with consistent accuracy. Differences continued to exist, however, in reading the isolated words they wrote. These isolated words were not necessarily the same as those the children wrote in their stories, and did not have a picture or word context. Beth, in particular, had difficulty sounding out words. Some differences in strategies are of note. Julian, the first grader, showed the most influences by the keyboard, few as they were, and spelled the greatest variety of words, having also requested the most new words to spell. He quickly progressed to the later phonetic stage of spelling. After his first story and second test, consonant only spellings did not occur although there was still an occasional omission of a vowel sound, e.g. TRKHEY/turkey in his fourth test.

In her interview, Julian's mother thought the computer experience was valuable for him, adding that his spelling development had been excellent through the year and that he likes to try new words. She also felt that his interest in the computer had been "high at first and then leveled off", describing him as an active child who "rushes through"

things at home and school. He has had extensive school experiences in "school programs" of one kind or another since he was a year old, began writing pictures with notes sometime in kindergarten, and has done well in spelling, reading, and math all year in the first grade. A computer was put in Julian's classroom this Spring, but his mother didn't know of any specific experiences with it. At home, she read to him in the "first months after birth", and his older sister has read to him. He has books of his own and borrows books from the school library.

Beth showed the fewest initial skills in spelling, producing several words that would be classified as preliterate or precommunicative spellings. She wrote CLEEAYRZ/heads, DHN/is, YULR/ran, UEYLLRPEAQBBURSAE for <u>the tree</u>, WAH/get, and AHT/of. Her progress in eliminating deviant spellings was not without relapses. She produced H/HEER/there in her second phase, then wrote a more deviant WPA, AOY and WAP before returning to a fairly systematic progression toward standard spelling: THA, TH, THER, THER, THERE, THERE, a relapse to THR and then consistent standard spelling afterwards. Beth showed modest progress at first and then a relatively sudden development of additional spelling strategies. After her first spelling test, Beth avoided responding to words on her tests that she was unsure of, although she was willing to attempt many of these same words in her stories, until her fourth test when she attempted all the words. New visual and advanced phonetic

skills showed up late and at the same time: inflected endings and phonetic spellings occurred for the first time in the fourth phase and subsequent test. Beth also made repeated use in her stories of the standard spellings she learned.

In her interview, Beth's mother said Beth "really enjoyed" her experience with us, had saved most of her printouts, sometimes colored them, and gave a couple to her brother. She mentioned that Beth has a "wandering eye at times when she looks up," takes longer to focus on things, had trouble learning to walk the balance beam, has had eye surgery, and may have surgery again. Her mother didn't think there was a keyboard at Beth's kindergarten, but Beth had done language experience activities there and had brought home pictures with her writing on them. At home, Beth's ten year old brother has a Texas Instrument 99A, which Beth occasionally has used to play games on for about a year or so, but she usually prefers to get a book. Her mother has read to Beth for 2 and a half years, but only since Christmas has Beth started to bring books to her and ask questions like, "What is this word? What does that mean?" Recently, Beth read a book to her mother for the first time, Spot's Favorite Colors.

In contrast to Beth, Kathy gained more control in her third story phase by avoiding words she did not know. Kathy showed a variety of whole word, segment, and phonetic influences early in her tests but few phonetic spellings

other than correct initial letters. Phonetic spellings, however, did show up early in her stories, which suggests that she may have given a higher priority to visual influences in her tests than in her stories, realizing that her phonetic spellings were in error and/or that the visual strategy was more reliable for a correct spelling. She also reduced the complexity of the spelling task in her stories by staying within the program vocabulary in her third phase before venturing again into words whose spelling she was unsure of in the fourth phase.

In her interview, Kathy's mother said that Kathy "loves" working on the computer and that Kathy told her, "Don't come to get me early." Her mother thought the computer "helped her tremendously," pointing out that Kathy can read a Dr. Suess book from beginning to end now, "writes all the time . . . loves to spell," and will orally spell sentences to communicate a request. Her mother didn't know of any computer in Kathy's classroom, and said Kathy has gotten "100s" in kindergarten since the beginning of the year. Both parents read to Kathy "since she was little."

Although he had more difficulty than Julian with the initial reading passage, James showed considerable whole word and phonetic skills from the beginning and never showed some creative spellings that would be expected. For example, although the other children did so, James never substituted a voiced D for a voiceless T in a tap when the standard spelling was T, even though the D would be more

accurate phonetically, e.g. in EITIN/eating, GATING/getting, WATR/water in his stories. In addition, James never made consonant only spellings except for SHN/shin in his first test.

James's mother felt he got a lot out of the program. He keeps his computer printouts, shows them off "quite often," and wants a computer for Christmas. He has done well in kindergarten, but has a "behavior problem." She did not know of any keyboard activities at his kindergarten. Before this year, he "played" occasionally on a typewriter at his mother's work. He has listened to cassette tapes of books for a couple years at home and can now sit down and read a book aloud. He also reads the TV guide.

Discussion

The results suggest that stage theories of spelling development need to be adjusted to account for visual strategies in more detail before the transitional stage. Several accurately spelled inflections, for example, occurred in words where the rest of the word is a semi-phonetic spelling. Beth, for example, spelled RNING/raining in tests and OING/holding, YING/walking and EING/watching in stories.

In addition, many standard spellings were not preceded by phonetic or transitional spellings. Before writing the corresponding standard spelling, Julian spelled HOUSE/horse in tests and PIRSET/picture in stories. Beth spelled B/bat and PAT/sat in tests and BEAT/boy, TH/her, and DHTN/IDHT/the

in stories. Kathy spelled TH/they and WLEK/walk in tests and GL/girl, H/HS/her, HMYS/horse, PA/pig, CSHT/STA/she, and WIA/WIE/with in stories. James spelled FIHA/fish in stories.

Nor were the creative variations that followed a standard spelling simply a relapse to a transitional or phonetic stage. Several standard spellings or near standard spellings were followed by creative variations that were not typical phonetic or transitional spellings: Julian spelled PESTE/picture in stories; Beth spelled SOG/dog, HEER/there then WPA/there in stories; Kathy spelled TRUICK/trick in tests and IS/THC/it in stories; and James spelled RIDG/RAIND/riding before coming closer again with RADING in stories.

Furthermore, sometimes only visual influences appeared in the development of a child's spelling. For example, in Kathy's sequence for it in her stories--IT, IS, IT, IT, IT, THC and then 12 standard spellings--the influences for creative variations seem to come from other words, e.g. is and the rather than phonetic spellings. Similarly, in James's sequence for going in his stories: GOING, GO, GO, and then 4 standard spellings, the only apparent influence is another form of the word. In addition, some of the common phonetic classifications like vocalized taps were absent or near absent in James's spelling development.

We also found alternating and simultaneous visual and phonetic influences in the spelling of words in the

children's stories. For example, the creative variations in Julian's spellings for picture, PIRSET/PICTURE/PESTE, contain a rather disorganized mixture of visually accurate letter elements and an S for an apparent phonetic representation of the /sh/ sound. Also, consider Julian's sequence for going: GON, GON then 4 standard spellings, then GOEN, GOING, GOINGN and 5 standard spellings. Before spelling GOINGN, Julian alternated between standard spellings and phonetic spellings. GOINGN contains both the standard spelling plus the N ending for the phonetic spellings. Beth's spelling for there shifts from a dominant visual approach, to an early phonetic reliance, to what appears as a developing integration of the two: H, HEER, WPA, AOY, WAP, THA, TH, THER, THER, THERE, THERE, THR, and then 10 consecutive spellings of the standard form. She writes one and then four of the five letters in there, H and HEER. Then she writes three variations that have none of the letters in there, but perhaps some phonetic correspondence of A for E in WPA, AOY, and WAP. Phonetic substitution of A for E then appears more strongly in THA. Afterwards, there is a steady progression in using the letters in there, TH, THER, THER, THERE, THERE, a relapse to THR and then 10 standard spellings.

These examples show that children have some flexibility in using either visual or phonetic strategies. This flexibility also shows in the tendency of the children to use more visual strategies in their tests. This is of

practical importance because it is generally agreed that good spellers in English must rely on visual strategies.

The appearance of these visual influences in the children's spelling may be at least partially explained by the experiences to which they were exposed. Children's reading strategies are strongly influenced by instructional strategies, and it is probable that spelling strategies can be similarly influenced (Marsh et al., 1980). For example, Bissex's (1980) son often asked for, and was told, the letters that made a particular sound. By contrast our children repeatedly saw the standard spellings in their DC and SPELL programs.

It should not be surprising then that children's spelling development may be affected by instructional programs on the computer. The computer has exceptional capabilities for making children aware of letter relationships in spelling. With no demands on handwriting and the fine motor control it entails, children can direct more attention to the spelling of a word. The letters in the words they spell also look more like the letters in their reading texts, which means their spelling is more readable. This allows children to more easily use information from reading in checking their spelling of words. The easily erasable words typed on a computer are also easier to revise, making it easier to spell words in different ways and to select what looks best. Writing down alternative spellings is a common adult practice that is

recommended in theory (Simon & Simon, 1973) and supported by empirical research (Tenney, 1980).

The computer can also provide feedback that is more detailed, immediate, consistent, and clearly interpretable than what can feasibly be expected from a teacher who is managing a class of many children. Exact records of each key a child presses and the latency between key presses provides useful information on spelling progress. Typically, the teacher only has the child's end spelling product to look at and little information of the process through which that product was obtained. There is little information on the nature of the child's revisions or on how long the child took to write the individual letters. The computer can also give children an immediate opportunity to correct or improve upon their spelling by giving them information for a correct spelling.

Programs with speech synthesis have additional advantages. Many children can benefit from checking their spelling more often, and programs with speech synthesis can make children more aware of what they have written, thereby increases the amount of editing they do in their writing (Clements, 1987). In addition, speech synthesis can give the letter name of the key that is pressed, the sound of the letter as it occurs in the word, the sound of word segments as they are spelled, and the sound of all the letters spelled so far. How much of this information and which of it would be useful still needs to be determined.

Finally, the computer easily lends itself to a highly individualized approach to spelling. There is no need to restrict children to the same list of spelling words. Instead, the spelling vocabulary can be adapted to each child's spelling background and interests. Each child can have a separate disk for spelling words. The vocabulary can be selected from words the child can read, words the child uses in writing, or words the child wants to know how to spell. Spelling can then be more closely integrated within each child's personal development in literacy.

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Authors' Note

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TABLE 1

CREATIVE SPELLINGS IN TESTS WITH THE NUMBER OF PREVIOUS OPPORTUNITIES TO SPELL THE WORDS IN THE DC AND SPELL PROGRAMS: JULIAN

WORD	QWERTY	DVORAK	QWERTY	DVORAK
AFTER	AEFTR 2/2			
AND	AD 4/4	AND 1/3	AND 1/1	
ARE	R 3/4		R 3/1	
ATE	AET 2/3	AET 2/9		ATE 0/1
BAKED				BAYKED 0/1
BAKES				BAYES 1/1
BALLOON	BI LLN 1/2		BLOON 2/3	BALLOON 1/4
BARK	BOR 2/2	BINE 2/2		
BIRD	BRD 2/3	BIDR 1/7		
BITTEN				BITEN 3/0
BOARD	BOR 2/2			
CHALK	COCK 4/5			
CLOUD	CLOUD 5/3	COLD 2/1	CLOWD 1/1	
COLD				COID 3/2
DISH			DISE 6/3	
EAT	EIT 5/3	EAT 2/2		
EATEN				EATIN 1/0
EATING		EATH 2/4		EATING 0/1
FALLS				FALLES 1/2
FENCE	FEBB 0/1	FECE 5/7		FNECE 2/1
FISH		FISE 3/2	FISE 4/0	
FLOWER	FLR 0/0	FOWER 6/4	FLOWER 4/1	FLOWER 6/3
GETTING	GETINN 1/1	GETTING 0/0		
GIRL	GILL 2/4	GRIL 6/3		
GOES		GOB 5/3		
GRASS	GAIS 3/6	GRASS 2/5	GRASS 15/3	
HAVING	HVN 2/0	HIVING 1/1		
HAY	HA 1/4	HAY 2/3		
HIS	HERE 2/2			
HOLD	HOD 0/1			
HORSE	HRSE 4/5	HOUSE 0/5	HORSE 6/7	HORSE 5/3
LOOK	LIK 3/3			
LOOKED		LOOKT 0/3	LOOKT 0/3	LOOKED 7/8
MOMMY	MOME 1/0			
NEAR			NERE 5/4	
OCTOPUS	OUKDIPS 1/0			
OVER		OVUR 4/0	OVER 3/0	
PAIL			PAIL 4/4	PIAL 1/0
PEPSI		PAPSEE 2/0		
PILGRIM	PUGN 1/1	PUGNR 1/0		
RAIN	RAN 3/2	RINE 6/2		
RAINING	RIN 0/1	RINE 1/0		
RAN	RUN 5/3		RAN 0/1	
ROOF	ROOFF 3/3			
RUN	RUNS 4/4	RUN 3/3	RUN 2/3	
RUNNING	RUNN 2/2	RUNNING 7/4	RUNNING 5/1	
RUNS	RUNS 2/4	RUNNS 6/6	RUNS 6/6	
SAID	SAD 1/2			SIDE 4/3
SAIL				SIAL 0/1
SAW	SAW 5/5	SOO 0/2	SOL 1/1	
SAYS				SIS 0/1
SEE	SEEE 4/2	SEE 1/3		
SHOWED				SHOWD 5/6
SLED			SLID 1/4	
SNOW	SOWN 3/1	SNOW 0/3		
SNOWBALL			SOWBAL 1/2	
SNOWING	SOWNING 1/1	SNOWING 1/0		
SNOWMAN	SOWMAN 1/2	SNOWMAN 1/4		
STAR	SOR 1/1	STRE 2/2	STAR 1/0	STAR 1/1
SWING	SRE ING 1/2	SWRING 1/0	SWING 1/4	SWING 3/5
TALK	TOIC 0/0	TOK 0/0	TOKE 1/0	
THANKSGIVING	TANKSGIVIN 1/2			
THERE			THER 3/1	THERE 9/6
THEY			THA 3/3	
THREE				THREE 3/3
TREAT	TEERT 2/4			
TRICK	TECK 5/3			
TURKEY				TREEMY 2/2
UMBRELLA	UONBILL 0/0		UNBOLLA 3/2	UNBRELLA 6/6
UNDER			UNDR 3/3	
WALK	WOCK 3/3	WALE 1/3		
WALKED		WALET 7/4	WALET 7/4	WALKED 2/8
WALKING	ROEING 1/2	WALKING 6/3	WALKING 6/3	WALKING 3/2
WALKS	WOKS 2/4	WALKS 3/8	WALKS 2/3	
WANT				WANT 2/0, WONT 2/0
WANTED			WENTED 4/3	WANTED 3/4
WANTS	WATES 1/0			
WATCHED			WONED 3/2	WATCHED 8/9
WATER		WALR 3/1		WATER 3/4
WENT		WIT 7/4	WENT 1/2	
WERE	RO 6/6	ROR 1/3	WERE 3/2	
WHEN				WIN 0/1
WHERE				WERE 5/7
WINDOW				WINDOW 4/4
WITCH	WITCH 6/5			WHTCH 2/3
WITH	WH 2/2	WITH 4/3		

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TABLE 2

CREATIVE SPELLINGS AND NO RESPONSES (NR) IN TESTS WITH THE NUMBER OF PREVIOUS OPPORTUNITIES TO SPELL THE WORDS IN THE DC AND SPELL PROGRAMS: BOTH

WORD	DVORAK	QWERTY	DVORAK	QWERTY
ALL				AL 2/4
AND	NR 4/6	AND 4/6		AND 0/2
ARE		NR 3/2		
AT	NR 1/0	NR 4/6		AT 1/3
BAD				BAD 1/1
BAR			BAR 1/1	
BAT		B 7/5	BAT 4/3	
BAY	NR 2/0			
BED				BAD 1/2
BY	BY 2/1	BO 5/6		
CAN			NR 1/1	
COW	NR 1/0	NR 5/3		
DEN	NR 1/1			
DOG	DOG 9/6	SOO 1/3		
EAT	NR 1/0			
FALL				FAL 7/10
FAR			NR 5/1	
FILL			FILL 5/4	FIL 6/5
FISH		NR 3/2		FISH 1/0
FULL				FOL 3/3
FUN				FIN 2/2
GIRL				
GO	GO 2/2	NR 6/3		GO 5/1
GOING			NR 6/7	GOING 5/6
HAD		NR 4/4		
HALL				HAL 3/2
HAS		NR 5/3		
HAY			NR 1/1	
HE			NR 4/4	
HEN			NR 3/3	
HER			NR 4/3	
HILL			HILL 7/7	HIL 2/2
HIT				HAT 7/5
HORSE		NR 1/2	NR 9/7	
HOT				HT 3/2
HOUSE		NR 2/4	NR 6/8	
ICE-CREAM				NR 1/0
ILL				AIL 3/1
IN	NR 6/6	NR 2/6	IN 1/2	
IT	NR 1/0	NR 5/4		
LOG		NR 4/5		
MAN		NR 4/3	NR 5/3	MAN 4/4
ME			NR 5/2	
MEN			NR 6/6	
MET				MAT 1/2
MOON		NR 2/1		
MOUSE			NR 5/6	
NO		NR 2/3		
NOT		NR 5/4		
ON	NR 1/0	ON 7/8		
ONE	NR 2/2			
PAN		NR 4/3	NR 2/3	PAN 6/7
PEN			NR 2/3	PEN 7/6
PIG	NR 0/1	NR 2/2		
PIN			NR 2/0	PAN 4/3
POT				PIT 2/2
PUT				PAT 2/2
RAINING				RNING 4/3
RAN	NR 4/9	NR 7/4	RAN 5/5	RAN 1/1
RUN	NR 7/7	NR 2/5	NR 2/4	RAN 2/2
SAND				SAD 1/2
SAT			PAT 5/6	SAT 3/3
SAW	NR 6/3			
SAY	NR 1/2			
SEE	NR 5/7	SEE 3/2		
SENT			NR 2/1	
SET				SIT 2/2
SHE			SHE 9/8	
SHEEP			SHEEP 5/5	SHEEP 4/4
SHIN			NR 2/4	
SLEEP				SLEEP 4/2
SNOW			NR 3/2	
SNOWING			NR 2/1	
STAR		NR 2/3	NR 4/3	STR 2/3
STAY			NR 1/1	
STIR				SR 2/4
SUN	NR 5/6	NR 5/6	SUN 4/2	
SWAN				SNW 2/0
SWIM				SVN 1/5
TALK		NR 1/5		
TELL	NR 1/0			
TEN			NR 4/2	
TENT			NR 2/1	
THAT		NR 5/3	NR 6/7	
THEN		NR 3/3	NR 4/1	
THERE		NR 2/4	THERE 6/9	THERE 0/1
THEY		NR 2/3		
TRAIN				TRN 4/1
TREE				TEE 4/2
TRICK				TRK 5/5
TRUCK				TRK 3/3
TWO		NR 5/1		
VAN			NR 1/3	VAN 2/1
VALE		NR 2/1	NR 2/2	
VALKED				VATKED 5/4
VALKING				VAIG 1/5
VANT			NR 4/4	
VANTED			NR 1/2	VTED 3/4
VAS	NR 5/7	VAS 6/3	VAS 6/3	
VASH				VIAS 4/5
VATCH		NR 4/2		VAI 3/2
VATCHED		NR 2/0		
VATER				VTR 6/6
VELL				VALL 5/5
VHERE			NR 7/9	
WILL			WILL 5/5	VALL 10/4
WIN			NR 2/1	
WISH				VIS 5/6

TABLE 3

CREATIVE SPELLINGS AND NO RESPONSES (NR) IN TESTS WITH THE NUMBER OF PREVIOUS OPPORTUNITIES TO SPELL THE WORDS IN THE DC AND SPELL PROGRAMS: KATHY

WORD	QWERTY	DVORAK	QWERTY	DVORAK
ANIMALS				A 1/2
ARE	NR 2/6			
BASEBALL				B 2/1
BAT	BOT 5/4	BAT 2/4		BAT 2/1
COLD				CLUD 7/6
DEN		DAN 1/1		
FISH	FIH 2/5			
GOT				NR 7/2, GOT 7/2
HAD	NR 5/2			
HAS	NR 2/5			
HEN		HAN 4/2		
HER		REH 2/5	HER 1/1	
LIGHTS				L 2/1
ONE	ONT 2/4			ONE 4/6
PAN	NR 3/5	PAN 3/4		
PEN		PIN 5/5		
SEE	SEES 4/6			
SHE		SEH 3/7	SHE 3/5	
SHIN		NR 2/3		
SHOVED				SOVED 3/4
SHOVING		SHOVED 6/6		SOVING 5/5
SHOWS				SOWS
SNOW		SNOV 4/3	SNWO 1/0	
SNOWING		SNOWND 5/2	NR 6/1	
STAR	SATR 4/3	STAR 0/4		
SWAN			SVAN 6/7	SAN 3/6
SWIM			SVAM 4/5	SIM 2/5
TALK	TOLK 4/3			
TEN		TAN 2/2		TEN 1/1
THAT	THT 3/2	THAT 5/4	THAT 7/7	
THERE	NR 2/3	NR 3/6	THERE 5/3	
THEY	TH 4/5	THEY 4/6	THEY 7/7	
THREE	HERE 1/4			TARE 4/1
TRAIN			TRIN 6/13	TRAIN 5/7
TRICE			TRICK 6/4	TRUICE 11/8
TRUCK			TRUCK 9/4	TURACK 5/6
TURTLE				T 2/2
TWO	TO 3/3			TWO 12/3
WALK	WAK 2/4	WLEK 4/6	WALK 6/4	
WASH				NR 6/9
WATCH	NR 3/3		WATCH 7/13	WATCH 11/8
WATCHED			NR 6/4	
WATER			WASTR 10/12	W 2/4
WHERE		WA 4/4		
WISH	NR 3/2			WITCH 5/9
WITH	NR 4/2		NR 7/5	WITH 4/2
WON				ONE 2/2

TABLE 4

CREATIVE SPELLINGS IN TESTS WITH THE NUMBER OF PREVIOUS OPPORTUNITIES TO SPELL THE WORDS IN THE DC AND SPELL PROGRAMS: JAMES

WORD	DVORAK	QWERTY	DVORAK
BEAR			BAER 2/2
CLOUD			CULOD 3/4
HER	HRA 8/1		
HORSE	HOUSE 8/6		
LIGHTS			LIGTS 2/1
PIN	PEN 3/1		
SAT	SEAT 2/2		
SAY	SAE 3/4		
SHIN	SHH 3/2		
SWAN		SWIN 1/3	SVAN 4/3
SWIN		SWAN 8/0	SVIN 1/0
TAPE			TAP 2/1
THERE	THERE 8/6	THER 8/9	
THEY	TEA 3/8	THEY 8/9	
TRACKS			TRAKS 1/1
TURTLE			TARTEL 2/2
TWO			TOW 8/8
WALK	VLAK 7/4	WALK 7/6	
WIN	VAN 2/3		
WITH		VIT 8/9	

TABLE 5

CREATIVE SPELLINGS IN STORIES WITH THE CORRESPONDING NUMBER OF STANDARD SPELLINGS INDICATED BY A NUMERAL: JULIAN

WORD	QWERTY	DVORAK	QWERTY	DVORAK
ABOUT				ABOT
*ABOVE				AUBOVE
*AFTER	IFTER/AFTAR			
*BABY				BABBY/1
*BEACH		BEH		
*BECAUSE				BECKE/BEACAES
*BEFORE		BOFR		
*BLUE		BALLLN		1
*BROWN				BOWNE
*BUNNY				BENT
BY		BYE/1	1	
*CHASING	IN CAS			
*CHRISTMAS		CHRISTMAN		
*CLIMB	CLN			
*DRUV				DROW/1
*EASTER				EASTTER/EASTTER
*EGG				AEG/AEG/AEG/AEG
*FEAST	FEST	FEBIT		
*FLIES				FLIS
GETTING		GET		
GIRL		1		GRIL/1/GRIL/ GRIL/2
GOBB		GOB		GOB
GOING		GON/GON/4/GOEN/1	GOINGN/6	
*GREEN			GREN	
*HANG				HINING
HAVE				AIF
*HIGH				HI/HI/HI
HIS		HES	1	2
HORSE	1	HARSE		2
INDIAN	INDIN/INDIN/1	4		
INDIANS	INDIAN			
*KIDS				KIBD
*LITTLE			LITL	
LOOK				LOK
*NIGHT		NIT		
ON	OAN/AON/7	7	9	3
*PASSED			PASST	
PAST		1	PASST/12	
*PICTURE				PIRSET/1/PESTE
PILGRIM	PEGN			
*ROOF	RAF/2			
SAID	SAD			
SAW	20		SON/1/SWA/6	1
*SCHOOL				SCOOL/1/SCOOH
TABLE		TABL		
TALK	2	TAIK		
*TEACHERS				TENRES
*TELL				TALE
THERE			THER/TER	1
*THINGS				THINES
*TOO				TO/TO/9
*VERY				VARRE
WAS	WOS/WOS/1	WOZ/WOI/WOI/WOI/ WOAS/11	16	4
WATER		2	WATRE	
WERE	WIR			
WINDOW			WENDO	

*Words that were not among the program vocabulary words the child had spelled.

TABLE 6

CREATIVE SPELLINGS IN STORIES WITH THE CORRESPONDING NUMBER OF STANDARD SPELLINGS INDICATED BY A NUMERAL: BETH

WORD	DYSRAE	CYRETT	DYSRAE	CYRETT
AND	N/1	7	27	27
*ANOTHER				A NAR
*ASKED			ARC/BAE	
AT				IAT/2
ATE	AET			
*BACK			BECK	
BARN			BAN	
*BEACH			BES/BEJ	BABS/BEGJ
*BESIDE				BSD
BIRD			BRAD/BORD	
*BIRTH	BELLBE			
BOAT			BAT	BOB
BOY	BBAE/B		2	2
*BROTHER			BUR/BRTHER	
*BUILT		BAD		
*BURNED	BERLLEA			
*BURNIES				BUBBY/BUBNYS/1
*CAME			EAM	
*CHAIRS		CHA		
*CHILDREN		CHR		
CLOUD	CLDE			
*COULD			KUN	
CON				COY
*CRIED		KRT		
*CUT		KRT		
DAY		DAE/DAE/S	18	14
*DID			DAB	
*DOWN			DOB/DAN	
*EXCUSE				XO
*FARMER				FMERR
*FEED			FAO	
FISH			FAS	
FLOWER				FOWER
*FLYING			FAEEN	
*FOR	FCIL	FR		
*GET			VAH	
*GOT		KLR	KIORT/1	
HAY			HTH	
HE		ES	HTC/1	
*HEARD	CLEEAYRZ			
HER		AR	HR/HAR/TH/1/HRE/2	2/HRE
*HOLDING				OTING
HORSE		HRS	HOANT/HOSHEAE/ HOES/HORS/1/HESE	HRSE/3/HOSE/6
HOUSE		HOS		
IS	DHH			
IT			AT	AT/1
*LITTLE		LTY	LAY/LATA/LATO/LEO	LTE/LITO/LITTE
MAN		MON	1	
*MILKING				MEKING
MOUSE				MAE/1
*OF			AHT	
ON			2/AN/1	8
*ONCE				ONECI/VBA/ONES/
ONE		OC/DA/ON/ OY/ONA/AEN	ON/DAN/1/OEN/OEN/ 6/OEN/6	ONES 14
RAN	YULR			
*RED				1/RAD
*RIDING			RIDEN	RID/1/RUTING
*SAID		SAD		SID/1
*SAILING				SAOLEN
SAW			SAL/SAL/VAS	3
SEE		NTE/SE	TH/TH/SHT/TS/SE/ SE/1/SE/6	5
*SITTING				SAN/SAITING
*SLIDING			SLED	
SNOWING			SNOSE	
SNOWMAN		SNAHN		
*SOME			SN	
*STANDING				SAENING
STAR			STR	
*STARING				SARING
STARS			STRS	
*TAKE		TAE		
THAT			THTET	
THE	DHTH/IDHT/**	8	8	25
*THEIR		DHR		
THERE		H/HEER/ VPA/AOY	VAP/THA/TH/THER/ THER/2/THR/10	21
THEY				THA
*TIME				TAM/TM/TAR/TIM
*TOLD			TAO	
*TOOK		TAE		
*TOP			TVI	
TREE	**			
TWO		TO	TO	TO/TOV/1
*UPON				APAN/A BIN/PAN
WALK		YE		
WALKED		OT		
WALKING				YING/VLEING
WATCHING				EING/YAEING/ VAEHING
WATER				YTR
*WAY				YE
WENT	N		WAT	
WERE		YR/YR		VIR/1/VIR

*Words that were not among the program vocabulary words the child had spelled.

**Typed UEYLLRPEAGKSBURSAE in response to "The tree"

TABLE 7

CREATIVE SPELLINGS IN STORIES WITH THE CORRESPONDING NUMBER OF STANDARD SPELLINGS INDICATED BY A NUMERAL: EATHY

WORD	QWERTY	DVORAK	QWERTY	DVORAK
APPLE	APPL	2		
*BEAR				BARN/S
*BIRDS		BARDS		
*BUILT	BUYTU			
*BUTTERFL				BADRFIA
*CHILDREN	CLHN			
*DAD	DADD			
*DARK	DARRK			
*DOWN		DAD		
*DRESS				CA
*DROPPED	J			
*EATING				ED/ETING
*FALLING		FLOO		
*FED	FDU			
FENCE	FORRE			
FIRE		FSR		
FLOWER	FLORL/FOLS			
*GARBAGE	GRBJ			
*GARDEN	GANTD			
GIRL	GL/IS	13	7	17
*GOOD				GEID/1
*GOT	GTD/ET	CGID		
GRASS	GERS			
HER	H/HS	1		
HORSE	HVYS	1/HOUR/2	3	1
HOUSE	HOYS		3	2
IN	N/2	2	3	2
IT	1/IE/2/THC/4	4	2	2
*KITCHEN				KE
*LIKED	LAD			
*LOOKED		LAT		
*MAGIC	MAJE	MAJE		
*MORE			MOR	
MOUSE		MOUS/1		
*OUT	2/OTA	AE		
*OUTSIDE	AROINS/			
	ORRDERRR/OTU			
*PET		PHT		
*PICKED	PSF/PE	PAIET		
PIG	PA	1		1
*PLANTED	PTOE/POUTD			
*PLANTING	PETET			
*PLAY	PLIA			
*PLAYED	PLD/PLAD/	PLLD		
*PRETTY	PRD			
*RAINED	RLEIYG/RJUIG			
*SAID	SATTD			
SAW	3	SIN/SLA/4/VAS/12	30	12
*SCRATCHE	SDIXTT			
SHE	CENT/STA/3	SEN	4	6
SHOVED	SHD	HOS		
*SITTING				SIDNINING
SLED		SED		
*SNOWED	SOF/SNOW D/SNOOD			
SNOWMAN	SIDE			
*SO	SHR			
*SONG	SONS		SAN	
*STARS	STAR/1/STRA	2		
*SWINGS	SWINGA			
*THAT'S	THEYER			
THE	6/THN/28	28	31	27
*THEIR	THER			
THEY	THAE/1/THA/THAA/THA	7	6	2
TO	3	2	TOO/2	4
*TOGETHER				TO GHTAR
*TOO		TO	3	
*TOOK	T			
TREE	THN			
TRICK	HRIK	TACK		
*UP	UOT/OU/1	1		
WALKING		VOE	1	4
WAS	VE/1	2	3	1/WIE/5
*WATCHED	VERTOG/VTRJUT/VITTY			
*WEARING				VRING/VINING
*WENT	WINT/VON/VONT/VLP/ VAPT/VAST/1/VNIT/VINT	VANT/VANT	VAT	
WITH	VIA/VIE/1	VTH		VIEN

*Words that were not among the program vocabulary words the child had spelled.

TABLE 8

CREATIVE SPELLINGS IN STORIES WITH THE CORRESPONDING NUMBER OF STANDARD SPELLINGS INDICATED BY A NUMERAL: JAMES

WORD	DVORAK	QWERTY	DVORAK
*ABOVE	ABOAN	ABAVE	
*ACROSS	ACREST		
*AIR		EARE	4
*AND	IAN/ENA/7	15	46
*ANIMALS	ANN	ANNAHALS	ANNAHALS/2
*ARE	OR/OR/IR/1	ARL/AER/1/AER/4	5
*AWAY	AVABO	2	1
*BACKYARD		BACYAIRD	
*BESIDE		BESID	
BIRD	BOT		1
BOAT	BOT		
*BY	BI/1	BYE/2	2
*CHAIRS			CARS
*CLOUDS		CLOADS	CLOUODS
*COMPUTER			CAMPUTER/CONPUTER/CONPUTER
*DISK			DISC/DISE
*DRESSED			DRAST
*DRINKING			DRAK
*EAT	EAOT/1		
*EATING	EITIN		
FAR	FOER	1	1
FENCE	FADNS		1
FISH	FINA	1	
FLOWER		FLAVER	3
*FLYING	FALIN/FLEING	FLEING/1/FLAING	1
*GETTING			GATING
GIRL	GISH/GARL/2	2	4
GOING	1/GO/GO/2	2	
*HEAD	HEDDA		
*HILL	HLA	HALL	HAL/HALL/1
*HOE			HALS
*HOLDING	HOLDIN		HALDING/HALING
HORSE	HORS	2	1/HORES
*IT	I/2	7	6
*LEAVES	LEVZAS		
*MEADOW			MADO
*MELTING			MALTING
*MIGHT	MIT		
*RAILROAD			RALRGAD
*RAINING	ROININ	1	3
*RIDING	1/RIDG/RAIND	RADING/RADING	
ROAD	1/RADD	1	
SAND	SANND		
*SAT	SAT	1	1
*SICK			CAK
*SLED	SILD		
*SMELLING		SMALING	SMALING
*SNAKE			SNAK
*SWIMMING	SIMEN	SEWNING	
*SWINGING	SVINGAN	SVINING/1	
TABLE			TABAL/TABAL/1
*THEIR	THUR	TIRE	
*TIME	TAME		
*TIMER			TIEMER
*TRACK	TRAKS		TRAK
TRACKS		TRIECS	
*TRAINS	TAROAS	1	1
TRUCK	TRACK	TAUAK	
UMBRELLA	UMBELLA		
*UNDER	UADR		ONDAR
WATER	WATR	1	1
*WEARING		WARRING	
*WILD	WIOD		

*Words that were not among the program vocabulary words the child had spelled.

TABLE 9

PERCENT OF STANDARD SPELLINGS ON SPELLING TESTS

Subject	Q	D	Q	D	Q	D
JULIAN	40% (32/81)	65% (49/75)	75% (51/68)	75% (53/71)		
BETH		36% (9/25)	26% (14/53)	33% (19/57)	29% (17/59)	
KATHY			58% (32/55)	77% (40/52)	82% (28/34)	65% (33/51)
JAMES				82% (42/51)	85% (23/27)	86% (42/49)

TABLE 10

WORDS THAT WERE ALWAYS SPELLED IN STARDARD FORM IN SPELLING TESTS OR IN STORIES (WITHOUT CREATIVE VARIATIONS OR NO RESPONSES)

STUDENT	TESTS	STORIES
JULIAN	A APPLE AT BAG BALL BAT BED BITE BOAT BOY BROOM BY CAR CAT COW DOG EATS FALL FALLEN FALLING FAT FED FLOOR GO GOING GOLD HAD HALLOWEEN HAND HAPPY HAS HAT HAVE HILL HILLS HOUSE IN INDIAN INDIANS IS IT JAR JUMPED JUMPING KITE KITTEN LAND LED LOG LOOKING MAN MEN MOON MOUSE NOT OF ON ONE OR PAN PEN PIG RED ROAD SAILBOAT SAND SAT SAYING SEEING SEES SHOW SHOWING SPOON SUN SWIMMING TAKES TEN THANKS THE THEM THINGS TO TOLD TRACKS TRAIN TREE TREES WAS WATCH WATCHES WOMEN	A AND ARE AT BARN *BE *BIG *BIKE *BLACK BOAT BOOK BOY BROOM CAN CAR CAT COW *CUT DOG *DOWN EATING *FOOTBALL *FOR *GATE *GET *GOOD GRASS *HE HILL HOUSE IN IS IT LOOKED *LAST *MAKES MAN *MOM *NEW *NICE NOT OUT PIG *PLAY PUMPKIN *READING ROAD SAW *SKY SNOW STAR *STORE SUN SURFBOARD *TAKE TALK *THAT TO TOP TREE TRUCK *UP VAN WATER *WE WENT WILL WITCH WITH
BETH	A ALL BAD BOY CAR CAT DAY FAT HAT MOMMY PAT SHE THE TO WALL	A *BUNNY CAT *DAD GIRL *GIRLS GO HAD HEN HILLS *IF IN *MOM MOMMY ON PAN PAN PIG SEE SHEEP TO
KATHY	A AND AT BABY BAR BEAR BOY BUS BY CAN CAR CAT CLOUD COW CUT DAY DOG DOOR FAN FAR FAT FLOWER FUN GO GOING HAT HAY HE HORSE HOT HOUSE IN IS IT JAR LOG MAN ME MEN MOMMY MOON MOP MOUSE NO NOT NUT OLD ON PIG PIN RAIN RAINING RAN RUN SAND SAT SAW SAY SAYING SHEEP SLEEP STOP SUN SWING TAPE THE THEM TO TOLD TOP TREE VAN WALKED WALKING WANT WANTED WAS WATCHING WIN WOMAN YOU	A AND ARE *AT BARN BIRD BOY *BUNNY BY *CAME CAT CLOUD COW *DADDY DAY DOG HAT HE HEN *HIS IS JAR MAN MOMMY MOON *NEW OLD ON ONE *PLAYING RAINING SAND SEE SHEEP SNOW SUN SWING *SWINGING THE WALKED WOMAN YARN
JAMES	ANIMALS BABY BAR BASEBALL BAT CAN CAR CAT COLD CUT DAY DEN DOOR FAN FAR FAT FLOWER FUN GOING GOT HAT HAY HE HEN HOT HOUSE IN JAR MAN ME MEN MOON MOP MOUSE NUT OLD ONE PAN PEN RAIN RAINING RAN RUN SAND SAYING SHE SHEEP SHOW SHOWED SHOWING SHOWS SLEEP SNOW SNOWING STAR STOP SUN SWING TEN THAT THEM THREE TOLD TOP TRAIN TREE TRICK TRUCK VAN WALKED WALKING WANT WANTED WAS WASH WATCH WATCHED WATCHING WATER WISH WITCH WOMAN WON YOU	*ALL BARN *BIRDS *BOATS BOOK BOY CAR CAT COW DOG *DOWN GIRL GRASS *GROUND HAT HEN HILLS HOUSE IN *IS KITE *LAYING MOUSE *OF *ON *OUT PIG *READING ROAD *SCHOOL SHEEP SNOW SNOWING SNOWMAN SUN SWING *THE *THREE *TO TOP *UNDER *YARD

*Words that were not among the program vocabulary words the child had spelled.

TABLE 11

CONTRASTIVE EXAMPLES OF CHILDREN'S SPELLING IN THEIR STORIES

STUDENT	FIRST PHASE	LAST PHASE
JULIAN	THE DOG WOS IFTR THE CAT ("The dog was after the cat.")	THE BOY IS RIDING HIS BIKE. THE GIRL IS RIDING HER BIKE TOO.
BETH	A BEAT YULR TO UEYLLRPEAQBBURSAE ("A boy ran to the tree.")	ONE DAY THERE WAS A BUNNY AND A GIRL AND THE BUNNY SAW THE GIRL AND THE GIRL SAW THE BUNNY
KATHY	TH GL J H APPL N THE GKR AND THE HWYS A IT ("The girl dropped her apple in the grass and the horse ate it.")	The girl is playing in the sand and she saw a bunny.
JAMES	THE FIHA IS SIMEN IN THE WATR INA DNA THE BOY IS IN THE BOT AND THE BOT IS FALIN FOER AWAEO. ("The fish is swimming in the water and the boy is in the boat and the bird is flying far away.")	the hill is in the air and the sun is in the air and the three birds are in the air and the house is on the ground and the fence is under the house.

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SPELL

TRAIN [] TIME.2.2.2.3.3
HOUSE [] TIME.3.4.4.6.6
SHOWED [SHOD] TIME.1.2.5.7.8.10.10
SWING [] TIME.2.3.3.3.3
TRUCK [TRUC HELP] TIME.2.2.3.4.4.4
WATCH [] TIME.1.2.3.5.6
FLOWER [FLOW HELP FLOWED] TIME.1.2.4.6.9.11.14.16
CLOUD [] TIME.2.4.6.6.6
WITH [] TIME.2.2.3.3
WATER [] TIME.2.2.4.6.7
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Figure 1. An example of a printout of the record of key presses for the SPELL program. Time refers to the cumulating number of seconds after the word is presented and after each subsequent key press until the word is spelled correctly. Underlined words were correctly read back aloud without help.

FPW.128

THE CAT AND DOG RAN TO THE FLOWER read back without help

Figure 2. An example of a printout of the pictures and sentence with the first story writing program, FPW.128. Underlined words were correctly read back aloud without help.

FASPIC.128

IT IS ROININ ON THE BOY.
IT IS RAINING ON THE BOY.

Figure 3. An example of a printout of the pictures and sentence with the second story writing program, FASPIC.128. The first sentence was written by the child without help, and the revision is underneath it. Underlined words were correctly read back aloud without help.